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Erosion from Upland Sources

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Introduction

The purpose of this paper is to discuss erosion on uplands, and the relationship between erosion and the sediment in rivers and lakes. The term uplands will be interpreted loosely as any area of the landscape not occupied by a river, stream or lake. Erosion is the detachment, transport and deposition of earth material. Erosion is highly variable in time and space and it is necessary to consider the scale of erosion when discussing the phenomenon.

Processes of Soil Erosion

Soil erosion is generally divided into two categories; wind and water erosion. These categories can be further subdivided based on the nature and scale of the process.

Wind erosion is generally thought of as being composed of two processes, saltation and aflation. Saltation is the physical bouncing of particles along the ground surface and tends to influence mostly heavier materials, such as sand and silt. Aflation occurs when particles are lifted from the soil surface into suspension in the wind. Aflation affects lighter materials, such as organic matter and silts, and to some degree soil aggregates. The role of wind borne sediment in the fluvial sediment regime has not been quantified but secondary evidence suggests that the contribution is often relatively small even from agricultural land in windy areas, such as the Cardston Plain in southwestern Alberta (Hudson and Askin 1987). Water erosion, on the other hand, can deliver considerable amounts of sediment directly to water bodies due to runoff.

Upland water erosion is divided into three processes; rill, interrill and gully erosion. Rill erosion is caused by concentrated flow of water over the landscape and results in the formation of small channels called rills. Rills tend to be on the order of 0.1 m deep , 0.2 to 3.0 m wide and up to several 100 m in length. On agricultural landscapes, rill erosion is often masked because conventional cultivation techniques eradicate them. Interrill erosion is the movement of soil between the rills and does not generally result in observable features on the land surface. Interrill erosion occurs on a scale of 0.05 m to 10 m in length. Rills grade into gullies. Gullies can be 10's of metres in depth and width, several 100m long and often form an impediment to cultivation. Gullies grade into stream channels. This process can result in very significant contributions of sediment to the rivers and streams (e.g. Upper Oldman river, Hudson and Askin 1987; Bow River basin, Luk 1975).

Deposition is a process that is inherent to erosion, but is often ignored or not considered in upland soil erosion studies. Deposition also occurs at a variety of scales. Continental denudation results from the removal of upland sediments by rivers. The ultimate depository of sediment are the ocean floors. On a more regional scale, lakes and other water bodies in the Province can serve as depositional environments for sediment eroded from the upland. Finally, on the upland itself there are numerous areas characterized by deposition resulting from rill and interrill erosion. Very little attention has been paid to these areas in the literature pertaining to upland soil erosion. These areas of deposition impede the movement of eroded soil from the upland into rivers and streams.

Approaches to Measuring Soil Erosion

A variety of techniques have been employed to measure or estimate soil erosion on upland areas. Plot studies are by far the most common technique for measuring erosion. In Alberta, Toogood (1963) and Chanasyk and Wotowich (1983) used standard sized Wischmeier plots to estimate water erosion in the Edmonton and Peace River regions,

respectively. Luk (1975) used a modified plot design to evaluate soil erosion in the Bow River basin. Plot studies are excellent for evaluating different treatments, such as cropping practice, on soil yield but do not separate the erosional processes (rill and interrill erosion). In addition, do plot studies do not give any indication of the fate of the eroded material.

The Universal Soil Loss Equation (USLE) was developed from plot studies that took place throughout the United States. The USLE is the most commonly used estimator of upland soil erosion. It is based on the evaluation of 6 factors (Rainfall, soil erodibility K, Slope gradient, slope Length, Cropping practice, and erosion control Practice). However, the applicability of the USLE is limited in Alberta. To date, there is no satisfactory method of including snowmelt processes or frozen ground conditions in an equation, yet most of the annual erosion and transport occurs during spring in Alberta.

The USLE is usually applied at a plot scale to derive estimates of average annual soil erosion. The equation has also been applied at a drainage basin scale. It must be noted that such applications generally ignore the partial area concept of sediment source areas as presented by Campbell (1983).

Recent studies by Howitt (1987) in East-Central Alberta have attempted to measure upland erosion and deposition processes. Soil erosion pans similar to those employed by Roels and Jonker (1983) were used to estimate the relative contribution of interrill erosion in an agricultural field. The rill meter, as described by McCool et. al. (1981), was used to measure the amount of rill erosion. Areas of deposition were identified and mapped in the basin based on rill patterns and soil properties. This approach to measuring soil erosion attempts to measure the processes of erosion and has value in identifying sediment source areas and depositional areas in the landscape.

Upland Erosion and the Sediment Cycle

It is clear from sediment yield studies that the amount of sediment in most rivers is substantially less than would be predicted using the USLE and the area of the drainage basin. There have been very few studies which attempt to link upland erosion and the sediment content of rivers and lakes. Hudson (1983) found that the major sources of suspended sediment in the Elbow River basin, in southwestern Alberta, were from channel and riparian erosion. The contribution from upland erosion in the forested upper basin and in the lower, agriculturally developed plains was found to be small. Similar results were reported by Hudson and Askin (1987) in the upper Oldman River basin. It was also found that significant sediment was derived from localized gully erosion. Luk (1975) reported similar results in the Bow River basin.

Martz and Campbell (1980) reported on the relative contribution of pipeline development on the sediment load in the Spring Creek watershed in the Peace River region of Alberta. The installation of a pipeline resulted in a 36% increase in watershed sediment yield over 4 months. Rill erosion was reported on the upland area of the pipeline development but this process had little influence on the overall sediment yield increase. Rather, slope failure was reported to be the dominant process in sediment delivery to the stream.

Howitt (1986) found that all of the soil material eroded by water in a small agricultural field was subsequently redeposited within the field. Areas of deposition in the basin had very thick depositional horizons characterized by buried Ap horizons (plow layer), separated by layers of sedimentation characterized by cross bedded sand and organic matter. In order for this basin to contribute to regional sediment yield, the water level in the slough at the bottom of the basin would have to be two to three metres higher than current levels. Martz (pers. comm.) reported considerable redeposition of soil in a research basin in

Saskatchewan and noted that a very intense storm would be necessary to dislodge the deposited material.

The upland is composed of a considerable number of sources and sinks for erosion and deposition. This can be demonstrated by considering the very thick Ah horizons developing in lower slope positions and depressions in the landscape. Further, an integrated and efficient drainage network is often not present to move material from eroding fields to the river. Hudson (1983) reported that in the lower reaches of the Elbow River sediment delivery from agricultural fields to the river was impeded by an inefficient drainage network.

In conclusion, the link between upland erosion and the sediment in Alberta rivers and lakes is not well defined. Current work suggests that the majority of sediment in rivers is the result of erosion in the channel or very close to the channel. Continued effort is required to clarify the relationship between upland erosion and sediment yield. The partial area concept of sediment source areas should provide a foundation for continued work.

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